Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/US05/002391

International filing date: 25 January 2005 (25.01.2005)

Document type: Certified copy of priority document

Document details: Country/Office: US
Number: 60/539,430
Filing date: 26 January 2004 (26.01.2004)

Date of receipt at the International Bureau: 03 March 2005 (03.03.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)

1287372

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

February 18, 2005

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.

APPLICATION NUMBER: ***60/539,430***
FILING DATE: ***January 26, 2004***
RELATED PCT APPLICATION NUMBER: ***PCT/US05/02391***

UNITED STATES PATENT AND TRADEMARK OFFICE · DEPARTMENT OF COMMERCE

Certified by

Jon W. Dudas

Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

EXPRESS MAIL NO. EL 981884621US

PTO/SB/16 (08-03)
Approved for use through 07/31/2006. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT und r 37 CFR 1.53 (c).

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Baron C.	**Dickey**	**Mercer Island, Washington**

☐ *Additional inventors are being named on the _____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

METHOD AND APPARATUS FOR SPATIALLY ENHANCING THE STEREO IMAGE IN SOUND REPRODUCTION AND REINFORCEMENT SYSTEMS

CORRESPONDENCE ADDRESS

Direct all correspondence to:

☒ Customer Number **22504**

OR *Type Customer Number here*

☐ Firm or Individual Name					
Address					
City		State		ZIP	
Country		Telephone		Fax	

ENCLOSED APPLICATION PARTS ***(check all that apply)***

☒ Specification *Number of Pages* 13 ☐ CD(s), Number ________

☒ Drawing(s) *Number of Sheets* 17 ☐ Other (specify) ________

☒ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☒ Applicant claims small entity status. See 37 CFR 1.27.

☒ A check or money order for $<u>80</u> is enclosed to cover the filing fees.

☐ The Commissioner is hereby authorized to charge filing fees to Deposit Account Number: **04-0258**

☒ The Commissioner is hereby authorized to charge any deficiency or credit any overpayment to Deposit Account Number: **04-0258**

☐ Payment by credit card. Form PTO-2038 is attached.

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: _____.

Respectfully submitted,			
SIGNATURE	Brian L. Johnson	DATE	**January 26, 2004**
TYPED or PRINTED NAME	**Brian L. Johnson**	REGISTRATION NO. *(if appropriate)*	**28,893**
TELEPHONE	**(206) 628-7739**	DOCKET NUMBER:	**60399-2**

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

EXPRESS MAIL NO. EL981884621US

PTO/SB/17 (10-03)
Approved for use through 07/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995,no persons are required to respond to a collection of information unless it displays a valid OMB control number.

FEE TRANSMITTAL for FY 2004

Effective 10/01/2003. Patent fees are subject to annual revision.

☒ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 80

Complete if Known	
Application Number	
Filing Date	January 26, 2004
First Named Inventor	Baron C. Dickey
Examiner Name	
Art Unit	
Attorney Docket No.	60399-2

METHOD OF PAYMENT *(check all that apply)*

☒ Check ☐ Credit card ☐ Money Order ☐ None

☒ Deposit Account:

Deposit Account Number: **04-0258**

Deposit Account Name: **Davis Wright Tremaine LLP**

The Commissioner is authorized to: *(check all that apply)*

☐ Charge fee(s) indicated below ☒ Credit any overpayments

☐ Charge any additional fee(s) during the pendency of this application

☐ Charge fee(s) indicated below, **except for the filing fee**

☒ Charge any deficiencies

to the above-identified deposit account.

FEE CALCULATION

1. **BASIC FILING FEE**

Large Entity Fee Code	Fee($)	Small Entity Fee Code	Fee($)	Fee Description	Fee Paid
1001	770	2001	385	Utility filing fee	
1002	340	2002	170	Design filing fee	
1003	530	2003	265	Plant filing fee	
1004	770	2004	385	Reissue filing fee	
1005	160	2005	80	Provisional filing fee	80
				SUBTOTAL (1)	($)80

2. **EXTRA CLAIM FEES**

			Extra Claims		Fee from below		Fee Paid
Total Claims		- 20** =		x		=	
Independent Claims		- 3** =		x		=	
Multiple Dependent						=	

Large Entity Fee Code	Fee ($)	Small Entity Fee Code	Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	86	2201	43	Independent claims in excess of 3
1203	290	2203	145	Multiple dependent claim, if not paid
1204	86	2204	43	** *Reissue independent claims over original patent*
1205	18	2205	9	** *Reissue claims in excess of 20 and over original patent*

SUBTOTAL (2) ($)0

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. **ADDITIONAL FEES**

Large Entity Fee Code	Fee ($)	Small Fee Code	Fee ($)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet.	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for *ex parte* reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	420	2252	210	Extension for reply within second month	
1253	950	2253	475	Extension for reply within third month	
1254	1,480	2254	740	Extension for reply within fourth month	
1255	2,010	2255	1005	Extension for reply within fifth month	
1401	330	2401	165	Notice of Appeal	
1402	330	2402	165	Filing a brief in support of an appeal	
1403	290	2403	145	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive – unavoidable	
1453	1,330	2453	665	Petition to revive – unintentional	
1501	1,330	2501	665	Utility issue fee (or reissue)	
1502	480	2502	240	Design issue fee	
1503	640	2503	320	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Petitions related to provisional applications	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	770	2809	385	Filing a submission after final rejection (37 CFR § 1.129(a))	
1810	770	2810	385	For each additional invention to be examined (37 CFR § 1.129(b))	
1801	770	2801	385	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify) ____

*Reduced by Basic Filing Fee Paid SUBTOTAL (3) ($)0

SUBMITTED BY				(Complete *(if applicable)*)	
Name (Print Type)	**Brian L. Johnson**	*Registration No. (Attorney/Agent)*	**40,033**	Telephone	**(206) 628-7670**
Signature	Brian L. Johnson			Date	**January 26, 2004**

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

METHOD AND APPARATUS FOR SPATIALLY ENHANCING THE STEREO IMAGE IN SOUND REPRODUCTION AND REINFORCEMENT SYSTEMS

FIELD OF THE INVENTION

The present invention relates generally to systems and methods for enhancing performance of sound reproduction and reinforcement systems and more particularly for enhancing the performance of these systems over broad listener areas.

DESCRIPTION OF THE RELATED ART

Since the advent of sound recording near the end of the nineteenth century, an effective methodology has been sought to make the reproduction of sound, especially music, approach as closely as possible the sound field created by the original live source. Challenges remain including increasing the audience listening area in which sound is faithfully reproduced. Sound reproduction system engineering implementations have focused on "electrostatic emitters" which are extremely directional in their radiation response and offer only a single listening location and electrodynamic emitters which have been designed for the uniform distribution of sound energy over a wide area.

Despite occasional announcements that the ultimate perfection has been reached and despite the increased number of separate emitters being utilized to create a theater or high-end home sound reproduction system, fidelity problems remain. Relatively accurate reproduction tends to exist. Unfortunately, it is restricted to central on axis listening positions, which are locations that are equidistant from primary emitters. For other listening positions spatial anomalies distort the associated sound field. With conventional approaches, for listening locations that are off the central axis of the emitters the "stereo image" degenerates. Consequently, for a group of original sound sources, such as instruments being played together, in a live performance the spatial orientation of the reproduced sound sources would not be the same as the spatial orientation of the live performance. Instead, the spatial orientation of the reproduction is compressed, expanded or otherwise changes relative to the spatial orientation of the original performance based upon listening position. In live performance sound reinforcement installations where emitters are used to reinforce the sound produced by instruments being played and singers' voices, performance frequently declines to the point where the emitters being used become the only acoustic image realized.

Since sound obeys an inverse square law relative to distance, as the distance between emitters and listener increases, the sound intensity decreases. As a result, the sound images that are created by two or more emitters at any listening position not equidistant from both emitters will have a geometry distortion introduced. In these off-axis listener positions, the instruments become crowded together and the instrument closest to the off axis listener becomes louder and the "stereo image" of central instruments rapidly degenerates. The incorporation of a third "center channel" has been tried, but this can add significantly to the system's complexity, and offers limited results.

A number of other devices have been proposed to increase the area in which the audience will experience faithful sound reproduction. Some have proposed the use of frequency sensitive elements to selectively phase shift and redirect the electrical energy

to various emitter means. The proposed devices tend to add complexity and degrade the final reproduced sound. Others have proposed devices that attempt to stimulate the listening room utilizing out of phase radiation from the emitter without regard to room dependant anomalies such as wave cancellations that occur from reflective walls to produce non uniformity.

Further, the industry has expended a great deal of effort measuring the effect of interaural time difference (ITD). This involves the time difference created by the physical path length difference created by the human head and the time differences created by the path lengths from sound source to listener. Various methods have been proposed to compensate for geometric anomalies. In modern recording studios it is common practice to use many microphones and recorder channels to capture a performance. Results can be disappointing since time and phase information that relate one instrument to another can be lost prior to recording distribution and is unavailable to sound reinforcement systems. As a result a less than ideal situation occurs in which differences in loudness of emitters are relied upon as the cues for spatial location to recreate sound image files. The challenge of increasing the audience listening area in which sound is faithfully reproduced remains by in large elusive.

DESCRIPTION OF DRAWINGS

Brief Description of the Several Views of the Drawing(S)

Figure 1 is schematic of a sound image of a sound image system and associated audience zones.

Figure 2 is a schematic of an emitter driving system of Figure 1.

Figure 3 is a general schematic of an emitter assembly of the sound image system of Figure 1.

Figure 4 is a flow chart of a calibration method for the sound image system of Figure 1.

Figure 5 is an exemplary schematic nonuniform sound amplitude emitted by the sound image system of Figure 1.

Figure 6A is a side elevational schematic of a first implementation of the emitter assembly of the sound image system of Figure 1.

Figure 6B is a front elevational schematic of the first implementation of the emitter assembly of the sound image system of Figure 6A.

Figure 7 is an exemplary schematic of the geometric relationship of two spaced-apart first implementations of the emitted assembly shown in Figures 6A and 6B.

Figure 8 is an electrical schematic of the first implementation of the emitter assembly of Figures 6A and 6B.

Figure 9A is a side elevational schematic of a second implementation of the emitter assembly of Figure 1.

Figure 9B is a front elevational schematic of the second implementation of the emitter assembly of Figure 9A.

Figure 10A is a schematic of a first electrical implementation of the second

implementation of the emitter assembly shown in Figures 9A and 9B.

Figure 10B is a schematic of a second electrical implementation of the second implementation of the emitter assembly shown in Figures 9A and 9B.

Figure 11 is an illustration of the relationship of an omnidirectional emitter array to the audience area and how the acoustic energy is apportioned. It illustrates the nonuniform sound amplitude emitted by each of two spaced-apart emitters with the sound amplitude as a function of angle represented by the distance of the arcs from the respective emitters.

Figure 12 is a front view of an implementation for small venues showing a plurality of emitters forming an array and with the high and mid frequency emitters divided into three bands.

Figure 13 is an electrical schematic associated with the emitter assembly of Figure 12.

Figure 14 is an illustration of the relationship of a pair of horn emitters and their relationship to the audience area.

Figure 15 is a section view of a horn radiator producing a non uniform radiation.

Figure 16 is an exemplary schematic nonuniform sound amplitude emitted by the sound image system utilizing a uniform emitter in cooperation with a nonuniform emitter.

DETAILED DESCRIPTION OF INVENTION

A sound image system and method is presented herein for spatially enhancing stereo image in sound reproduction and reinforcement systems typically used such performances as those involving music. The sound image system seeks to expand the amount of audience area that would receive a sound image that maintains sound reproduction fidelity regarding spatial orientation of sound sources involved in an original performance. To expand the audience area receiving spatially faithful sound reproduction certain characteristics of sound have been first studied to find important factors involved.

Frequency, phase and amplitude can all play a part in a human's ability to accurately determine the location of a sound source. It is generally accepted that wave frequency defines tonality and must be faithfully reproduced. It is also recognized that when all sound energy comes from a single emitter, the listener will be able to accurately locate the sound source regardless of listener position. Here the path length difference to each ear of the listener and thus the loudness sensed by each ear is dependant upon the orientation of the listener's head to the sound source.

In another case of multiple emitters where each emitter reproduces sound representing a different sound source relatively positioned at the location of the emitter, the reproduction is still faithful regardless of listener position. It is when one attempts to create the illusion of a sound source that is relatively positioned in a location other than a location of an emitter that image problems generally occur. An ideal case for conventional approaches is when listeners are equidistant from two or more emitters so that they receive correct amplitude information in the well known stereo effect. For conventional approaches, it is when a listener is not equidistant from the emitters and therefore have path length differences, that sound level anomalies occur.

Implementations of the sound image system uses emitter assemblies each having a collection of emitters arranged to produce a non-uniform sound amplitude radiation pattern which are collectively used together to reduce these anomalies. Other implementations use a mixture of emitter assemblies with at least one having a non-uniform radiation pattern. The non-uniform patterns of the emitter assemblies of the sound image system are fashioned so that for any location in an audience listening area, each emitter assembly furnishes sound amplitudes at the location that are approximately equal to the sound amplitudes furnished by the other emitter assemblies of the sound image system for the location. To accomplish this requires a nonuniform amplitude distribution pattern from at least one of the emitters assemblies based upon the relative distances of the listener from the emitters.

In the following implementation these anomalies are substantially corrected using a non-uniform sound amplitude radiation pattern generated by the emitters to produce equal amplitudes at the listener from the respective emitters. This requires a nonuniform amplitude distribution pattern from at least one of the emitters defined as a function of the relative distances of the listener from the emitters.

In the implementation shown in Figure 6, this unequal amplitude distribution will vary, not only from side to side, but as a function of the listener distance to the emitter pair, which, translates to a vertical angle as shown in Figure 7, to keep the correction substantially valid at all emitter to listener distances.

In the implementation shown in Figure 1 these anomalies are compensated using emitter arrays (16-20) in cooperation with an Emitter Driving System, EDS (12) . This should be done while maintaining a substantially uniform frequency response, at least over the range of frequencies in which the listener is reliant for location information.

In this system an EDS (12), shown in Figure 2, includes a sound source (30), such as a compact disk player providing an electrical signal representative of an audio signal. A multi channel amplifier (32) to provide the requisite energy to power the emitter arrays (16-20) and an Emitter Energy Apportioner, EEA (34). The EEA (34) may be a part of the amplifier, a functionality of the emitter array ,EA, or as an element located anywhere within the EDS (12), to distribute the energy to the emitter arrays (16-20).

One implementation of an EEA (34) contains a resistive network used to apportion energy from one set of emitters to an other set of emitters as shown in Figure 9a. A Variable resistive element (94) placed in shunt with an emitter set to be diminished in amplitude (42b) causes less energy to be received at the shunted emitters. As the variable resistive element (94) is reduced in resistance the other series emitters (42a) will receive more energy. Thus by varying the value of the variable resistive element (94) the energy apportionment may be varied. An additional resistive element (96) may be placed in series with the variable resistive element (94) to limit the extent to which the energy may be unequal.

The EA's (16-20) are placed before an audience area (22), as shown in Figure 1. EA "A" (16) is depicted as the left most array. EA "B" (20) is depicted as the right most EA with dimension r (70) being the distance between. EA's which may be located between are designated item (18). The central axis (28), which is defined as all points equidistant from the left an right EA's, bisects the audience area. Since the sound anomalies are

dependant upon the EA to listener distance (78,80) the audience area (22) may be further divided into zones 1-n (26). Zone 1 is designated as the near field zone and is bounded by the near field compensation border (23).This represents the boundary at which maximum correction is defined. At the other extreme are the most distant listener locations and are referred to as the far field zone (26). This zone is limited by the far field compensation border (24) and is the distance limit from the EA's at which the anomalies are substantially compensated.. Between these two zones are located any further compensation zones (26).

The anomalies in each audience area are compensated by causing the EA to direct more or less acoustic energy to that location. As the listener position moves further from the central axis (28), the compensation will increase. As the off axis listener position varies from the near field boundary (22) to the far field boundary (24), the compensation will decrease. A typical implementation is shown in Figure 6. The EEA (34) provides the directional non uniformity horizontally to correct anomalies intra zone and vertically, angle "D" (88) to correct anomalies inter zone, as shown in Figure 7. Since low frequencies contain no special location content they may be reproduced separately using omni directional emitters (50).

One implementation includes the following steps, as shown in Figure 4. Install at least two emitter arrays, left and right (62). To provide more than one compensation zone these will be located above or below the audience plane. Supply a stage reference input to the EDS (64). This signal should simulate a sound source located between the emitter arrays. Select a zone and symmetrically adjust the drive energy to the band emitters via the EEA (34) for an off axis location (66). If this is done ratiometrically, all locations within the zone will be corrected. Repeat the process for each zone. By making the EEA ratiometric, that is, what ever energy reduction is made in one direction, a proportional increase will be made at a complimentary direction. Additionally the left EA "A" (16) will be the complementary mirror image of the right EA "B" (20) as shown in Figure 5. When these relationships are followed system adjustment can be reduced to only one adjustment per zone.

The most sensitive indicator of correct compensation is when a sound source e.g. a solo instrument or singer, is equidistant between the EA's and the selected audience location is near the left or right extreme. At this location a listener may direct the system adjustment so that the soloist sounds to be equidistant between the EA's. Alternatively acoustic measurements may be made of each EA to ensure equal sound levels at the selected listener position.

The subject disclosure teaches that, it is more important to distribute emitter drive energy according to how the listener perceives the sound field than according to the tradition of distributing the energy as a function of the response of the emitters. This is most commonly seen in the traditional electrical networks, dividing low frequency energy to one set of emitters and high frequency energy to another set of emitters.

The polar graph in Figure5 represents such resultant nonuniform radiation patterns from a pair of emitters. These patterns are tailored to alter the radiated sound energy as a function of direction in a fashion opposite to that introduced by the geometry distortion and are shown as matching in amplitude but complementary in direction for the two emitters arrays "A" (16) and "B" (20). Figure 5 graphically shows the non

uniform distribution from the implementation shown in Figure 3.

The necessary correction in emitter amplitude from two EA's, "A" (16) and "B" (20) are evaluated as follows. We let A(16) and B(20) represent locations of EA's that are electrically driven as a stereo pair and C (76) represent an arbitrary listening position, as shown in Figure 5. Further, we let r (70) represent the distance between A and B, s (80) the distance between B and C, t (78) the distance between A and C, and □ (86)the angle between lines AB and BC. Then,

$$t^2 = r^2 + s^2 - 2rs \cos \square$$

Given that sound amplitude decreases with the square of the distance from an emitter, then at C the sound from EA "A" (16) decreases by 1/s2 and the sound from EA "B" (20) decreases by 1/t2 . To accurately recreate sound images along line r, the EA at "A" must have an amplitude different from that of the AE at "B" by a factor, f, of (t2/s2), or

$$f = (r/s)^2 + 2(r/s) \cos \square.$$

The sound amplitude radiated by each EA (Ac) (82,84), in acoustic units (db), as a function of angle will be:

$$Ac= 10 \log ((r/s)^2 + 2(r/s) \cos \square.)$$

The method described herein provides the necessary sound dispersion corrections without compromising the fidelity of the reproduction devices utilized in its implementation. To provide proper amplitude corrections over a large audience area (22), EA's "A" and "B" are displaced from the audience plane, as defined as the locus of all listener positions within the audience area (22), so that, as the listener distance varies, so will the emitter angle to the listener, angle "D" (88) and correspondingly the loudness correction. It will be recognized that as the audience depth , C1 to Cn, increases so will angle "D"(88) and the required variation in correction will also change. In small venues such as a home, EA's "A" (16) and "B" (20) may be co located in the listener plane while still offering amplitude corrections as the listener position varies left and right of the central axis.

To create the desired non uniform radiation pattern from the nine element array shown in Figure 6, some emitters (42a) must receive more energy than others (42b). In this implementation the emitters (42) are divided horizontally to serve three " zones"(26) . One set of emitters are vertically oriented toward the far field zone, "zone3", . A second set "1" is vertically oriented toward the closest listener area, Zone 1, the near field zone. The remaining emitters comprise a third set that is oriented toward an intermediate listener area as shown in Figure 7. These sets are orthogonally subdivided into three bands. Band "A" represents all emitters (42a) oriented toward the listener area requiring increased radiation and band "B"(42b) represents all the emitters oriented toward the listener area requiring decreased radiation. Band "C"(42c) represents all the emitters that require no alteration of their radiation. The EEA in this implementation provides the means for adjusting the distribution of drive energy between Bands A (42a) & B (42b) and therefor the desired non uniform radiation is shown in Figure 5. The EEA (34) using electrical elements to apportion the electrical energy is preferable to use of dissimilar emitters since it allows adjustment for listening environment and allows all emitters (42) to be identical. . In this implementation a frequency selective

apportioner (92) diverts the low frequency energy to low frequency emitter (50) and also diverts the mid and high frequency energy to the EEA and thence to the EA emitters (42) that form Zone 1. This energy is similarly diverted to each of the other EEA's the serve Zones 2 -n. The EEA for each zone may be used to adjust the compensation as a function of horizontal angle 2 (86) to compensate anomalies at varying listener positions within the zone (26).

An implementation for small listening venues, illustrated in Figure 12, incorporates a plurality of emitters to form an array that can approximate the response of an acoustical four pi steradian point source. Such an array lends itself to an implementation as it radiates in all directions with a uniform frequency response and is easily adjusted to produce a wide variety of radiation patterns as shown in Figure 11. In this implementation vertically facing low frequency emitter (50) in an appropriate enclosure (51) to control the out of phase emissions operates in cooperation with an ellipsoidal reflector (110) to reproduce the low frequency portion of the spectrum with omni directional radiation. The mid and high frequencies are reproduced by a plurality of emitters (42) situated on that ellipsoid to form an array. If all emitters receive equal drive energy, the sound energy will be equal in all directions as depicted as a circle (72) in Figure 11. To create the desired non uniform radiation pattern (74) from this array, some emitters (42a) must receive more energy than others. In this implementation the emitters (42) have been divided into three" bands" . Band "C" (42c) is vertically oriented orthogonally to the inter array axis (A-B). Band "A" represents the emitters (42a) oriented toward the listener area requiring increased radiation and band "B"(42b) represents the emitters oriented toward the listener area requiring decreased radiation. In this implementation the EEA for adjusting the distribution of drive energy and therefor the desired non uniform radiation may be similar to the one shown in Figure 9b. Using electrical elements to redistribute the electrical energy is preferable to use of dissimilar emitters since it allows adjustment for listening environment and allows all emitters (42) to be identical. . In this arrangement a frequency selective apportioner (92) diverts the low frequency energy to low frequency emitter (50) and also diverts the mid and high frequency energy to the EA (34). The emitters in the array are divided into three bands. The central emitter band "C" (42c), which are not amplitude altered and two variable bands of emitters "A"(42a) and "B"(42b). The redistribution of sound energy is depicted as an ellipse (74) in Figure 11. This implementation offers no compensation as a function of room depth but compensates only on a single curve before and and a matching curve behind the speakers or on the central axis (28) where no amplitude correction is required. The extent that a further listener is not on those curves, the amplitude will be unequal though it will be an improvement over systems without amplitude compensation. This configuration does not incorporate separate Zones related to listener distance. Since vertical distribution angle is not a consideration the emitters may be co located in the listener plane and may be more appropriate for many small listening environments such as a home. In the distance relationship given above, if s (80) and t (78) are chosen to be much greater than the inter speaker distance, r (70), it is seen that the errors occurring on such large arcs will suffer only a slight degradation and that for most purposes they can be ignored.

As a further implementation the radiant energy can also be restricted vertically in a more conventional radiation pattern where the majority of the sound energy is directed toward

the audience. Figure 9 depicts a representative implementation achieving the desired nonuniform amplitude pattern. In this implementation two low frequency emitters (50) are oriented toward the listening area. Three emitters (42) to reproduce the mid and high frequencies are oriented with one intended to be toward the listening area and the other two oriented; one to the left and one to the right. Utilizing an EEA more energy is distributed to one of the angled emitters (42a) and less to the other angled emitter (42b). This creates the non uniform energy distribution desired in this disclosure and is shown in Figure 5. In this implementation the overall system is shown in Figure.10. In this implementation the EEA causes one emitter (42a) to receive less drive energy and emitter (42b) will receive more. Additionally the low frequency emitters (50a) and (50b) may be adjusted to redistribute the sound energy as a function of angle by incorporating an EEA as shown in Figure 10.

As an additional implementation a refractor horn(120) as shown in Figure 15 may be utilized in place of the afore utilized arrays. In this implementation the essentially uniform radiation of an emitter (126) is intercepted by a refractor horn with non uniform dimensions and redirects the acoustic energy to the listening areas with a nonuniform intensity. The EEA in this implementation is a property of the asymmetrical construction of the refractor horn. The nonuniform energy apportionment is determined by appropriate selection of the horn entrance (122) and exit areas (124) . As depicted in Figure15 the horn exit areas (124) are equal and the entrance angles and areas (122) are varied as a function of angle and illustrates only one of many possible combinations that, to those skilled in the art, would be known to achieve the same result. As depicted entrance D (122d) is the smallest and will therefor direct the least acoustic energy to its corresponding exit. Entrance A (122a) is the largest entrance and will therefor direct the largest amount of acoustic energy to its corresponding exit (124a). Entrances B(122b) and C (122c) are proportioned to the areas of A and D. Thus, the desired directivity may be achieved by purely mechanoacoustic means, without associated electronic components or signal processing. The horn designer selects the apportionment and the EEA is a property of its design. A typical installation would consist of two or more horn emitters installed as complementary pairs

An implementation can consist of only one nonuniform emitter as shown in Figure 16. In this configuration one emitter array, selected for purposes of demonstration as emitter array "B", generates a non uniform radiation to compensate for emitter to listener distances. Emitter "A"has a uniform radiation pattern, emanating substantially uniform energy toward the audience area. This implementation while demonstrating that all the compensation can be provided by only one nonuniform emitter array also demonstrates that there exist a continuum of divisions which can correct the spacial anomalies. This implementation does however suffer from a variation in overall sound intensity when a listener position is changed. When the listener moves from left to right he will experience a decrease in overall sound intensity. As the anomaly correction becomes more evenly distributed between the emitter arrays, the intensity variation tends to diminish.

Passive absorption materials placed between the emitter and the listener constitute a further implementation which may be used to accomplish a non uniform sound radiation pattern. If the emitters do not have the proper non uniform radiation, an adjustment of

energy transmitted from a emitter can be made by passive absorption materials placed between the emitter and the listener as illustrated in Figure. 10. The absorption material is graduated in absorption ability, varying absorption as a function of angle, selectively absorbing radiated sound energy from the emitters to produce the required a sound distribution pattern. This can take the form of a plate of contoured acoustic foam giving position dependent absorption. Any acoustically absorbing material, such as those used in the noise reduction industry, would be a suitable alternative to acoustic foam. Examples include pads or blocks of acoustic fiber, e.g., polyester or bonded acetate, and polyurethane and polyester foams of a range of densities. The acoustic mask is preferably of a material that does not propagate the acoustic output from the radiator, i.e. the mask is preferably acoustically semi opaque and nonresonant. The acoustic mask may be co-extensive with the resonant panel. The distance between the mask and the panel is preferably as small as possible consistent with creating the desired nonuniform pattern.

From the foregoing it will be appreciated that, although specific implementations of the invention have been described herein for the purposes of illustration, various modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

CLAIMS

Having described the invention, I claim as follows:

1. A sound reproduction system comprising at least two sound sources, at least one of said at least two sound sources emitting an acoustical sound wave with a nonuniform amplitude distribution pattern, the sound sources together producing an area remote from the respective sound sources including points non-equidistant from the at least two sound sources where amplitudes received from the at least two sound sources are approximately equal at points within the area.

2. The sound production system of claim 1 wherein at least one sound source further comprises a plurality of sound sources radiating acoustical waves in nonparallel directions and in unequal amplitudes.

3. The sound production system of claim 1 wherein the amplitude of a first acoustical wave emitted from a first sound source in a first direction is a multiple of the amplitude of a second acoustical wave emitted from a second sound source in a second direction intersecting the first acoustical wave within said remote area at a point of intersection, the multiple being a function of the relative distances of said first and second sound sources from said intersection.

4. A sound reproduction system comprising at least two sound sources and a mask between the sound source and said area toward which the sound source is directed, the mask having an nonuniform absorption capability yielding an acoustical wave emerging therefrom having a nonuniform amplitude distribution, the sound sources and the mask together producing an area remote from the respective sound sources including points non-equidistant from the at least two sound sources where amplitudes received from the at least two sound sources are approximately equal at points within the area.

5. The sound reproduction system of claim 3 wherein distance, t, between the point of intersection within the remote area and the first sound source is a function of distance, s, between the point of intersection within the remote area and the second sound source.

6. The sound reproduction system of claim 5 wherein said function is in accordance with the following relationship

t2 = r2 + s2 - 2rs cos (theta)

where :

r represents the distance between sound sources at A and B,

s the distance between B and C, a listener location,

t the distance between A and C, and

q the angle between lines AB and BC.

7. A sound reproduction system producing a sound image at a plurality of listening locations within an area remote apparently emanating from a point equidistant between the sound sources, the system comprising at least two sound sources including a plurality of directional sound sources, arranged such that amplitudes of sound waves from the respective sound sources at points within the remote areas are approximately equal.

8. The sound reproduction system of claim 7 comprising two sound sources respectively representing left and right stereo sound signals with directionally nonuniform wave amplitude distribution patterns wherein each of the two sound sources comprises a plurality of acoustical wave loud speakers.

9. In a sound reproduction system including a plurality of sound sources, the method of obtaining remote areas non-equidistant from the sound sources where acoustical wave amplitudes received from said plurality of sound sources are approximately equal, comprising the following steps:

a. Positioning said plurality of sound sources before the remote areas;

b. Adjusting the acoustical wave amplitudes emanating from the sound sources as a function of direction to create an amplitude distribution pattern varying with direction of emission yields approximately equal amplitudes received within said remote areas.

10. The method of claim 9 wherein the radiation from each source varies substantially in accordance with the formula t2 = r2 + s2 - 2rs cos (theta)

where :

r represents the distance between sound sources at A and B,

s the distance between B and C, a listener location,

t the distance between A and C, and

(theta) the angle between lines AB and BC.

11. The method of correcting listening anomalies experienced at listening positions that are unequal distances from multiple emitters in sound reproduction systems, comprising the following steps:

a. electrically driving two or more emitters by conventional left and right stereo electrical signals;

b. Placing an acoustical mask between at least one sound source and listening

positions that absorb acoustical energy a function of direction of radiation of said at least one sound source such that radiated sound energy from said two or more sound sources effectively balance at a listener location in said direction;

12. The method of claim 11 wherein the radiation from each sound source passing beyond the acoustical mask varies substantially in accordance with the formula t2 = r2 + s2 - 2rs cos (theta)

where :

r represents the distance between sound source at A and B,

s the distance between B and C, a listener location,

t the distance between A and C, and

(theta) the angle between lines AB and BC.

13. A sound reinforcement or reproduction system of claim 1 wherein the sound sources are displaced from the plane of the listening positions.

14. A sound reinforcement or reproduction system of claim 2 wherein the sound sources are displaced from the plane of the listening positions.

15. A sound reinforcement or reproduction system of claim 3 wherein the sound sources are displaced from the plane of the listening positions.

16. A sound reinforcement or reproduction system of claim 4 wherein the sound sources are displaced from the plane of the listening positions.

17. A sound reinforcement or reproduction system of claim 5 wherein the sound sources are displaced from the plane of the listening positions.

18. A sound reinforcement or reproduction system of claim 6 wherein the sound sources are displaced from the plane of the listening positions.

19. A sound reinforcement or reproduction system of claim 7 wherein the sound sources are displaced from the plane of the listening positions.

20. A sound reinforcement or reproduction system of claim 8 wherein the sound sources are displaced from the plane of the listening positions.

METHOD

21. the method of claim 9 wherein the additional step of positioning said sound sources out of the plane of the listening areas is added.

22. the method of claim 10 wherein the additional step of positioning said sound sources out of the plane of the listening areas is added.

23. the method of claim 11 wherein the additional step of positioning said sound sources out of the plane of the listening areas is added.

24. the method of claim 12 wherein the additional step of positioning said sound sources out of the plane of the listening areas is added.

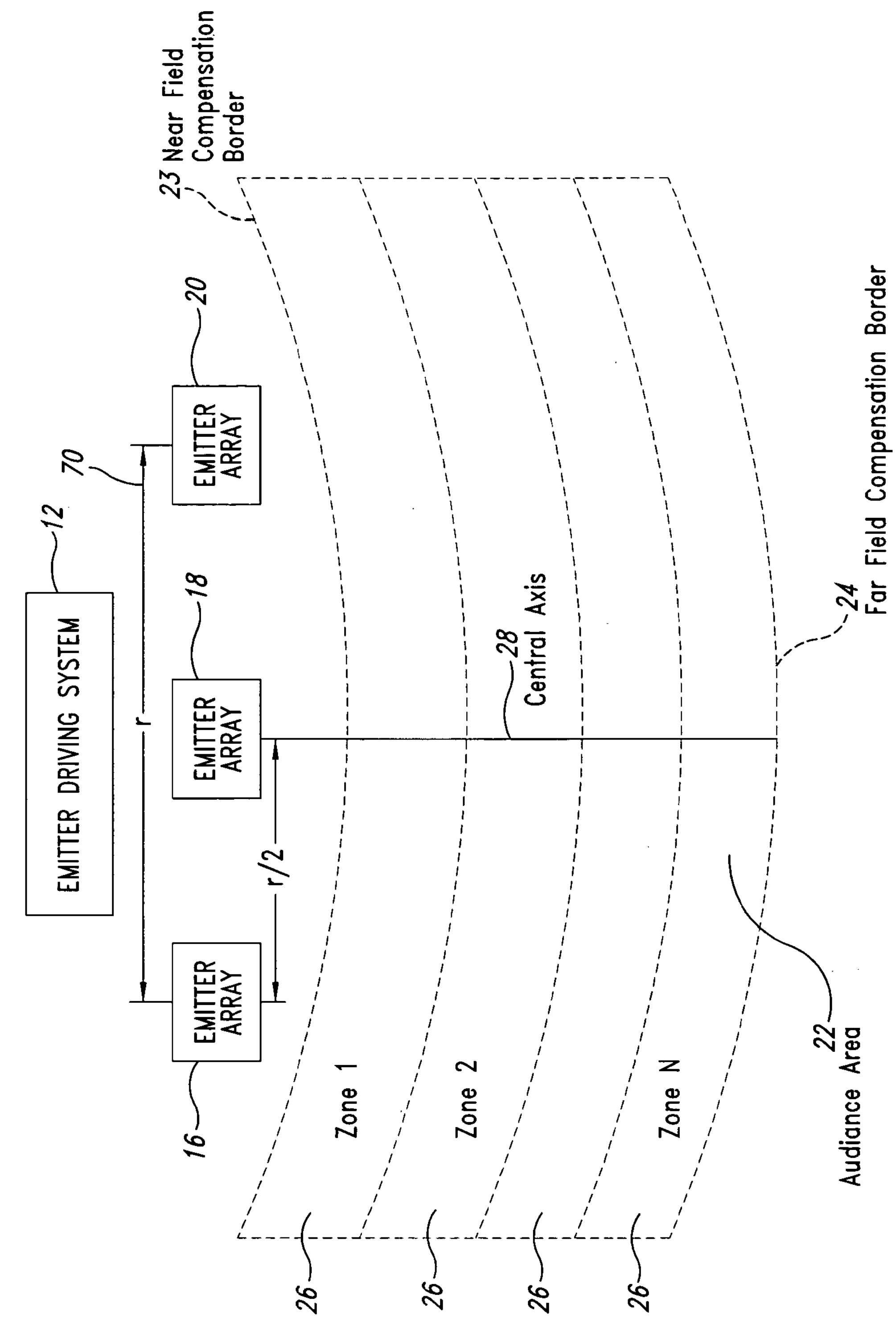
EMITTER DRIVING SYSTEM
12
70
r
EMITTER ARRAY
16
EMITTER ARRAY
18
EMITTER ARRAY
20
r/2
23 Near Field Compensation Border
28 Central Axis
24 Far Field Compensation Border
Zone 1
Zone 2
Zone N
22 Audiance Area
26
26
26
26

Fig. 1

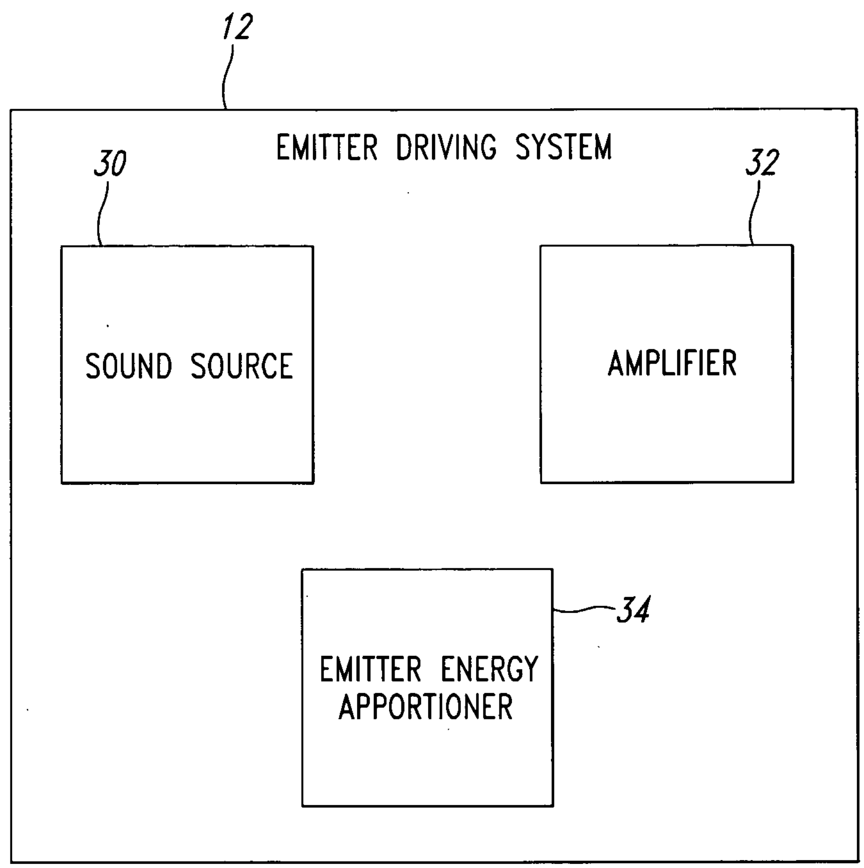
12
EMITTER DRIVING SYSTEM
30
32
SOUND SOURCE
AMPLIFIER
34
EMITTER ENERGY APPORTIONER

Fig. 2

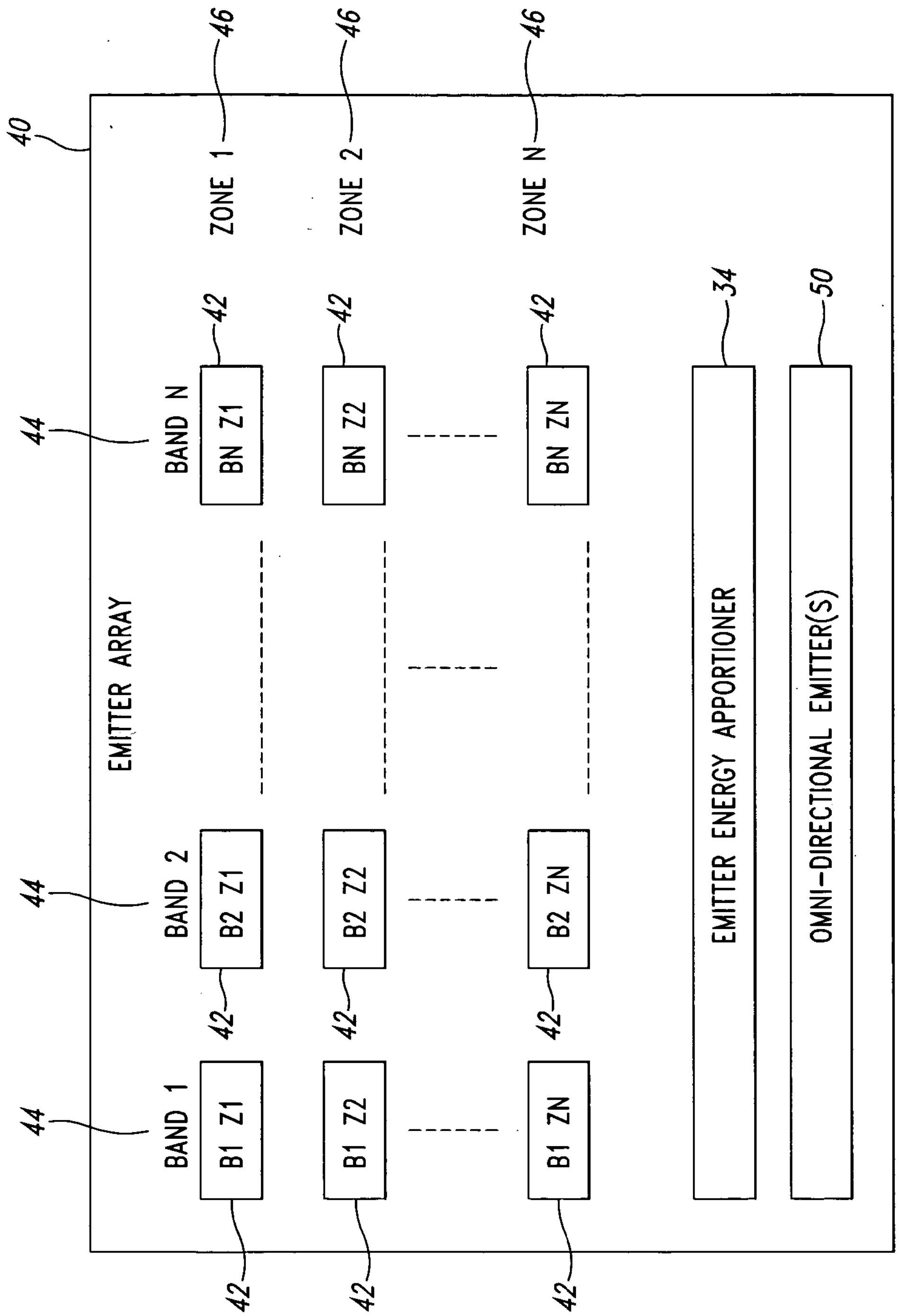
40
EMITTER ARRAY
44
BAND 1
BAND 2
BAND N
B1 Z1
B1 Z2
B1 ZN
B2 Z1
B2 Z2
B2 ZN
BN Z1
BN Z2
BN ZN
42
46
ZONE 1
ZONE 2
ZONE N
EMITTER ENERGY APPORTIONER
34
OMNI-DIRECTIONAL EMITTER(S)
50

Fig. 3

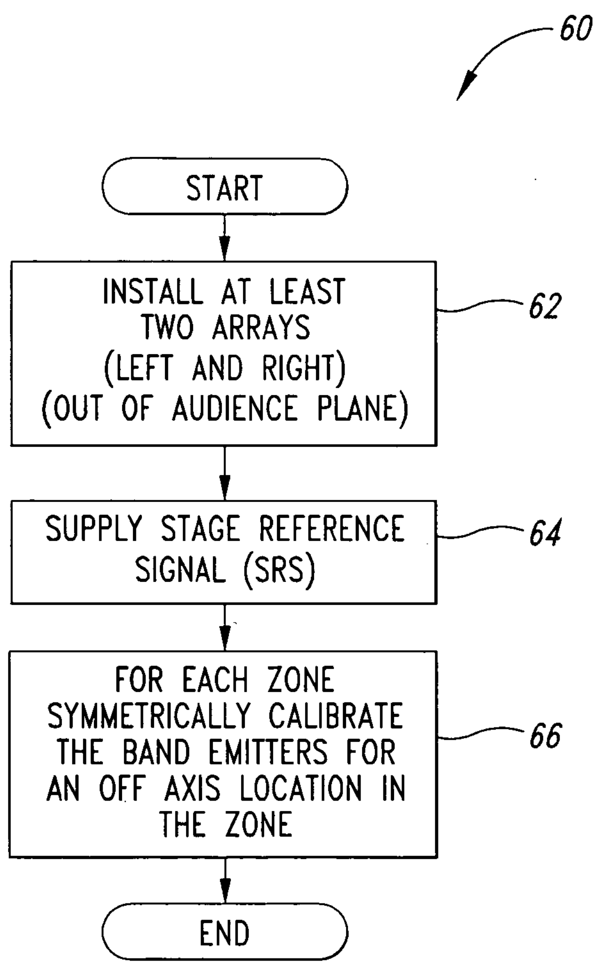
60
START
INSTALL AT LEAST TWO ARRAYS (LEFT AND RIGHT) (OUT OF AUDIENCE PLANE)
62
SUPPLY STAGE REFERENCE SIGNAL (SRS)
64
FOR EACH ZONE SYMMETRICALLY CALIBRATE THE BAND EMITTERS FOR AN OFF AXIS LOCATION IN THE ZONE
66
END

Fig. 4

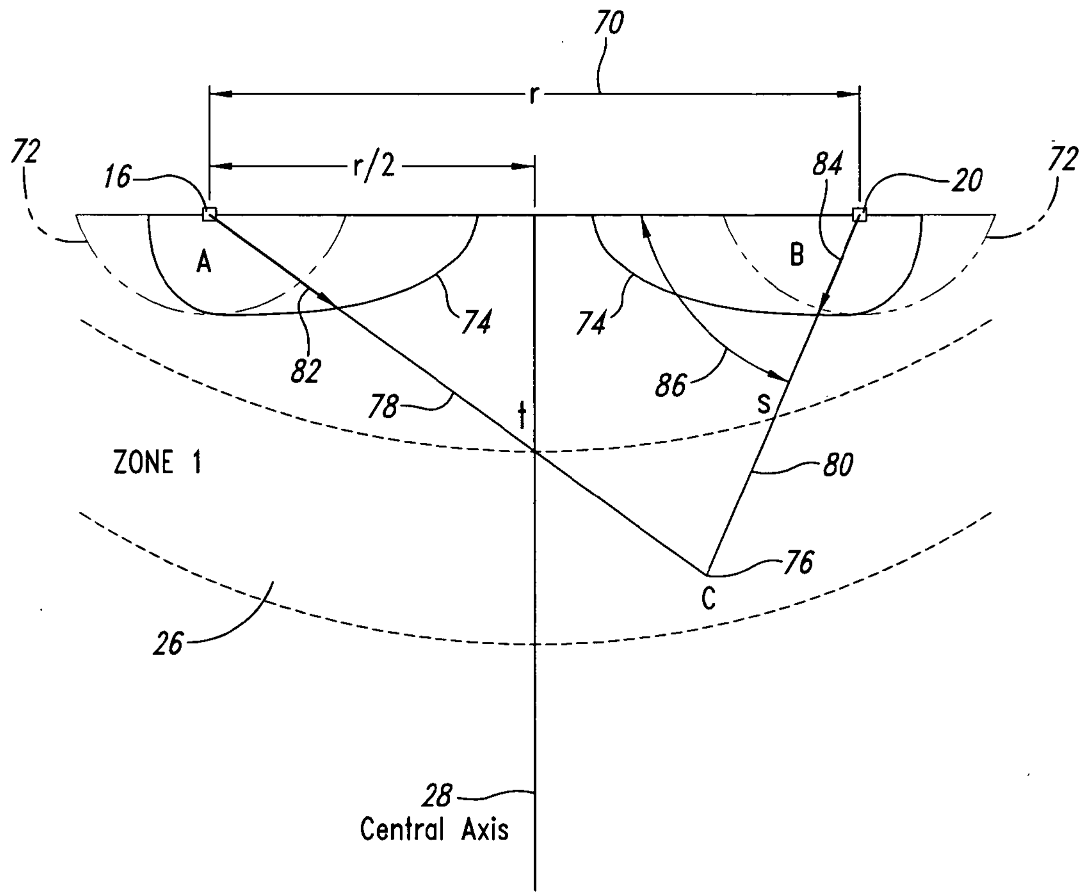
70
r
72
16
r/2
84
20
72
A
B
74
74
82
86
78
t
s
ZONE 1
80
76
C
26
28
Central Axis

Fig. 5

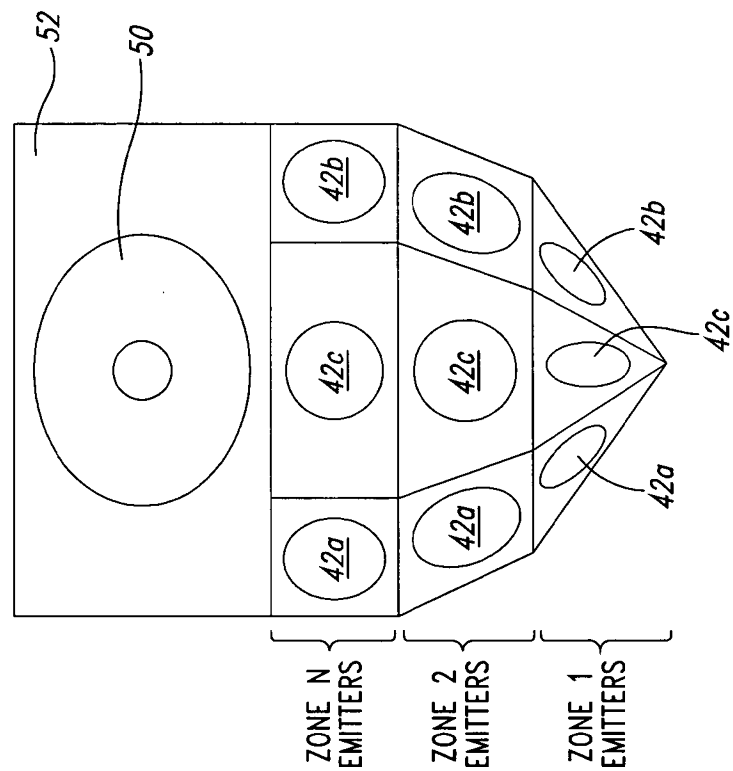
52
50
42b
42c
42a
ZONE N EMITTERS
ZONE 2 EMITTERS
ZONE 1 EMITTERS

Fig. 6B

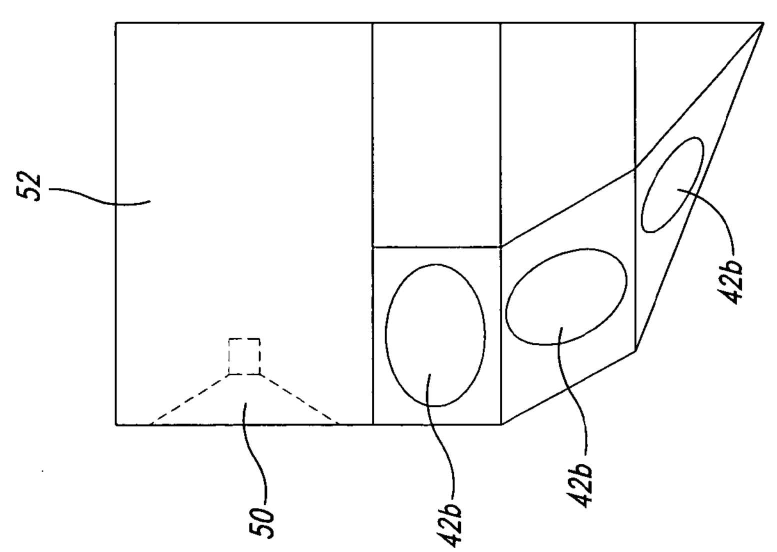
52
50
42b

Fig. 6A

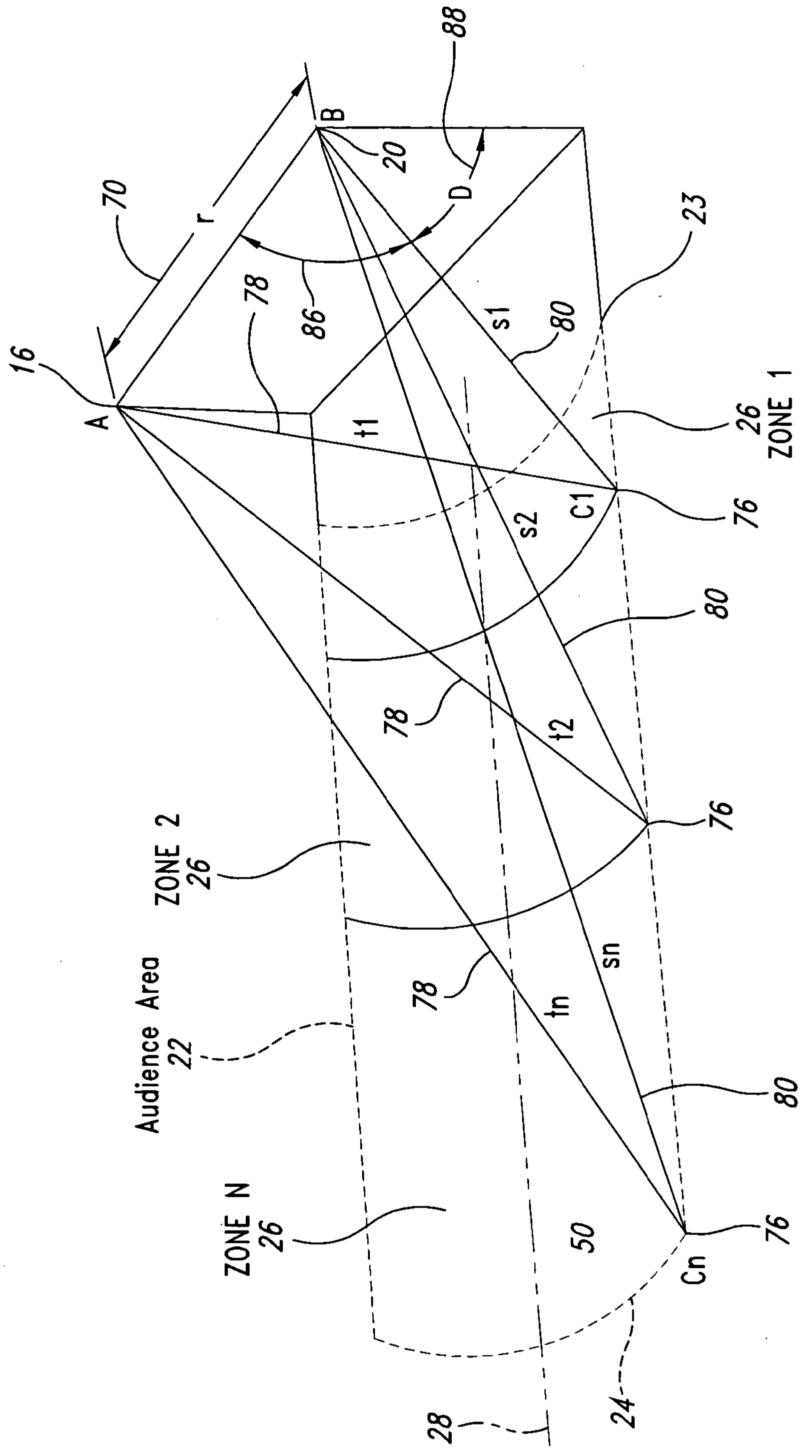
A
B
16
20
70
r
88
D
86
78
23
s1
80
t1
26
ZONE 1
C1
76
s2
80
78
t2
76
ZONE 2
26
sn
78
tn
Audience Area
22
80
ZONE N
26
50
Cn
76
28
24

Fig. 7

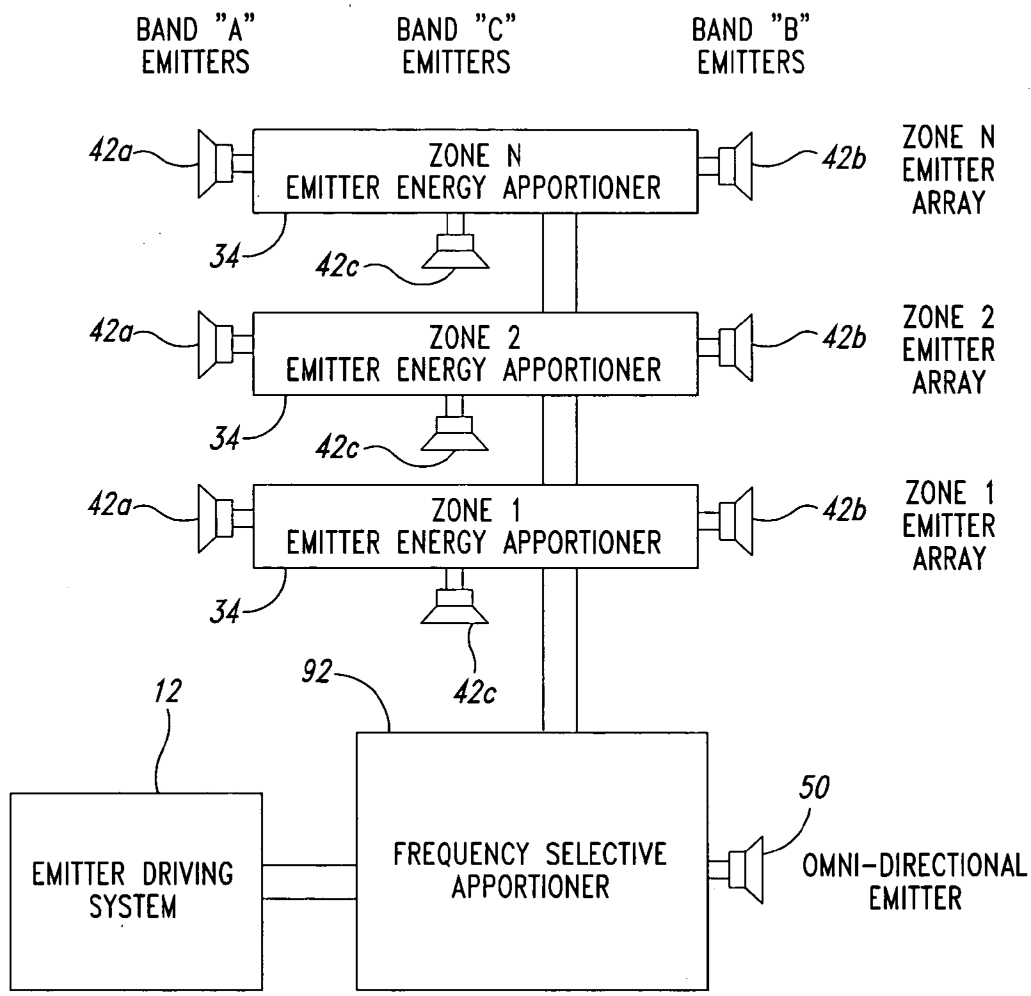
BAND "A" EMITTERS
BAND "C" EMITTERS
BAND "B" EMITTERS
42a
ZONE N EMITTER ENERGY APPORTIONER
42b
ZONE N EMITTER ARRAY
34
42c
42a
ZONE 2 EMITTER ENERGY APPORTIONER
42b
ZONE 2 EMITTER ARRAY
34
42c
42a
ZONE 1 EMITTER ENERGY APPORTIONER
42b
ZONE 1 EMITTER ARRAY
34
92
42c
12
EMITTER DRIVING SYSTEM
FREQUENCY SELECTIVE APPORTIONER
50
OMNI-DIRECTIONAL EMITTER

Fig. 8

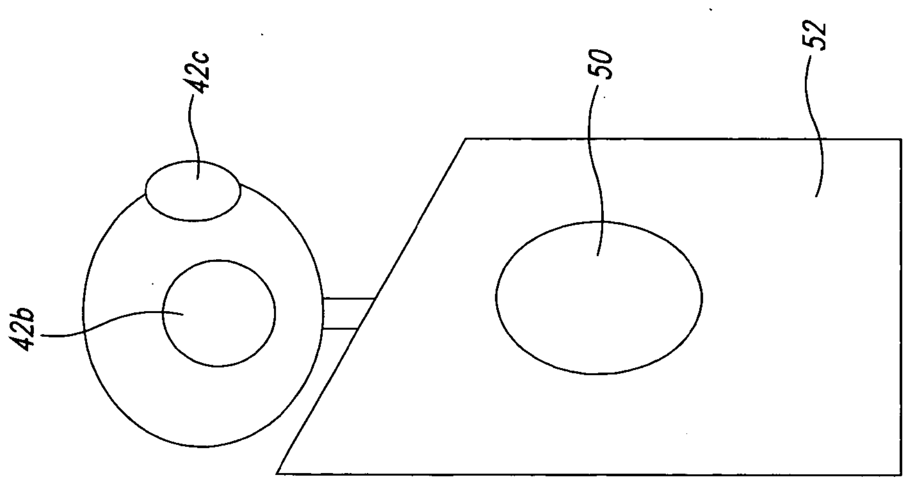

Fig. 9A

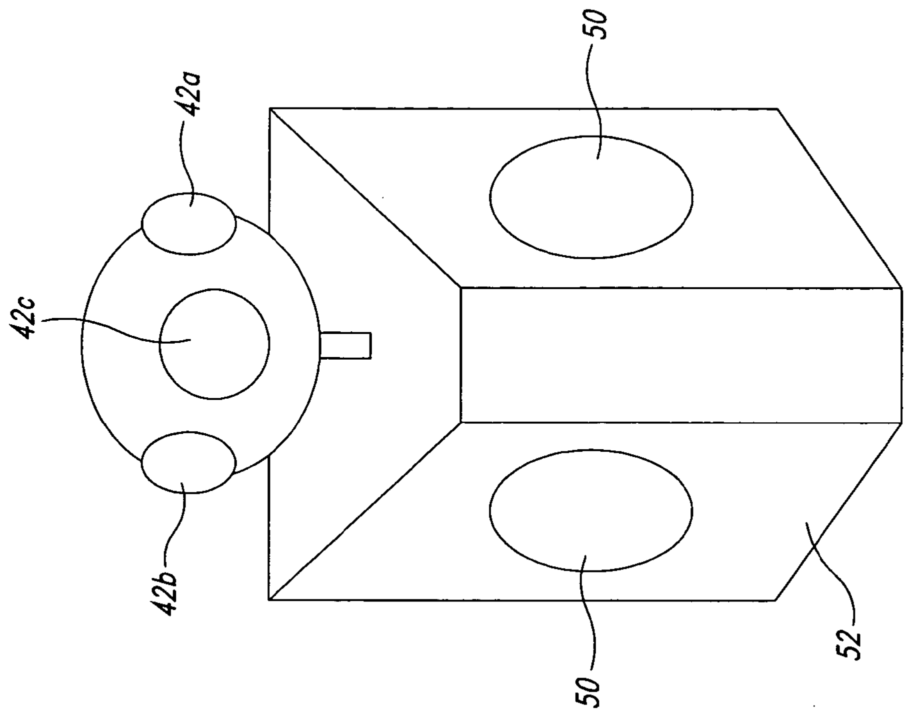

Fig. 9B

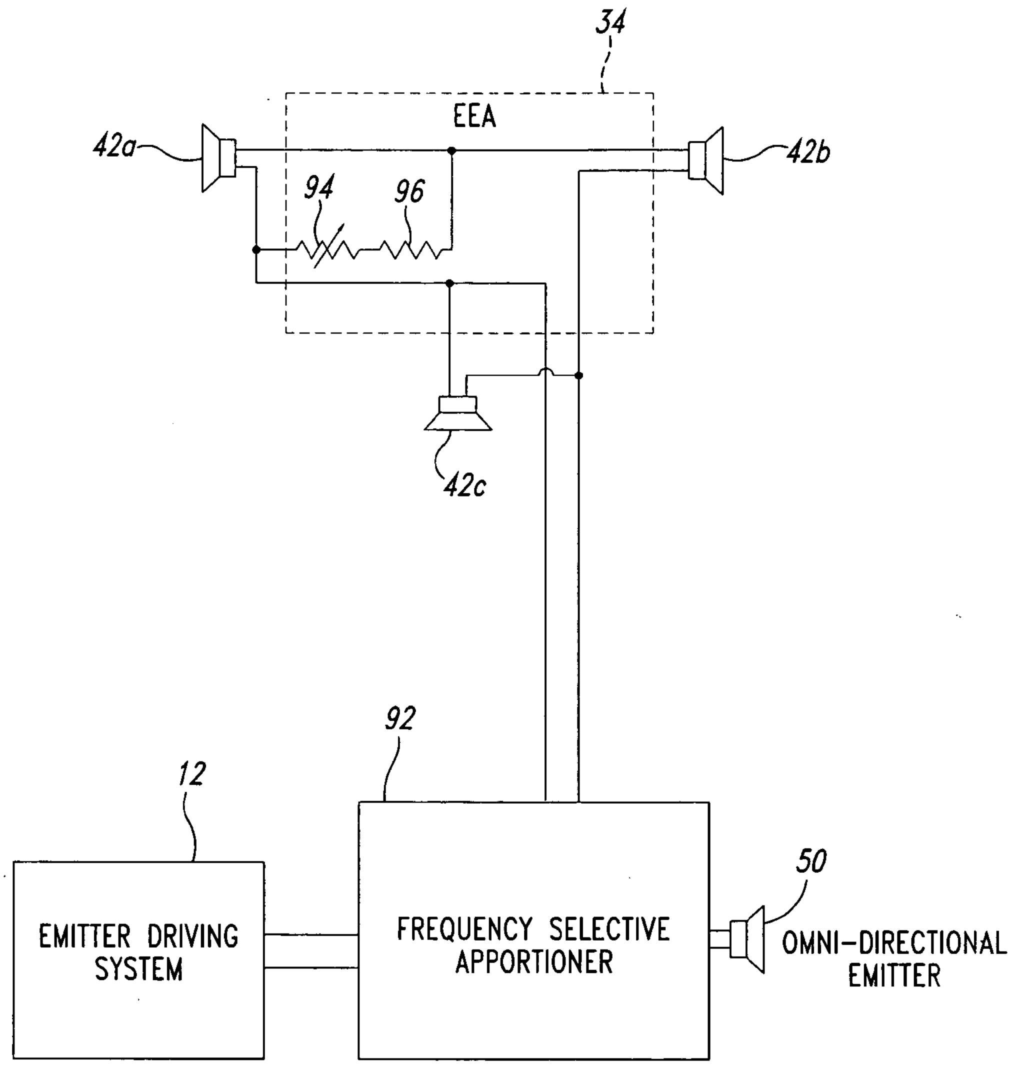
34
EEA
42a
42b
94
96
42c
92
12
EMITTER DRIVING SYSTEM
FREQUENCY SELECTIVE APPORTIONER
50
OMNI-DIRECTIONAL EMITTER

Fig. 10A

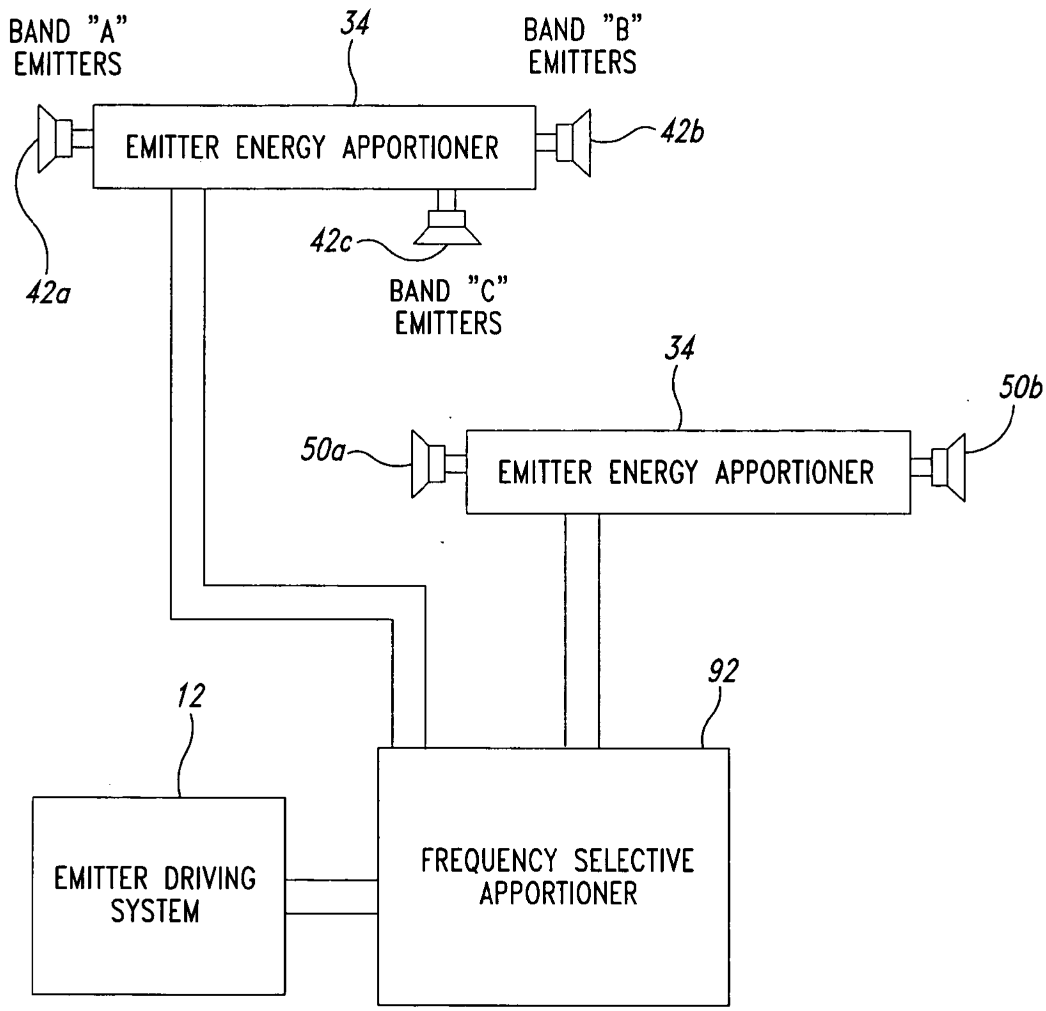
BAND "A"
EMITTERS
34
BAND "B"
EMITTERS
EMITTER ENERGY APPORTIONER
42b
42a
42c
BAND "C"
EMITTERS
34
50b
50a
EMITTER ENERGY APPORTIONER
92
12
EMITTER DRIVING
SYSTEM
FREQUENCY SELECTIVE
APPORTIONER

Fig. 10B

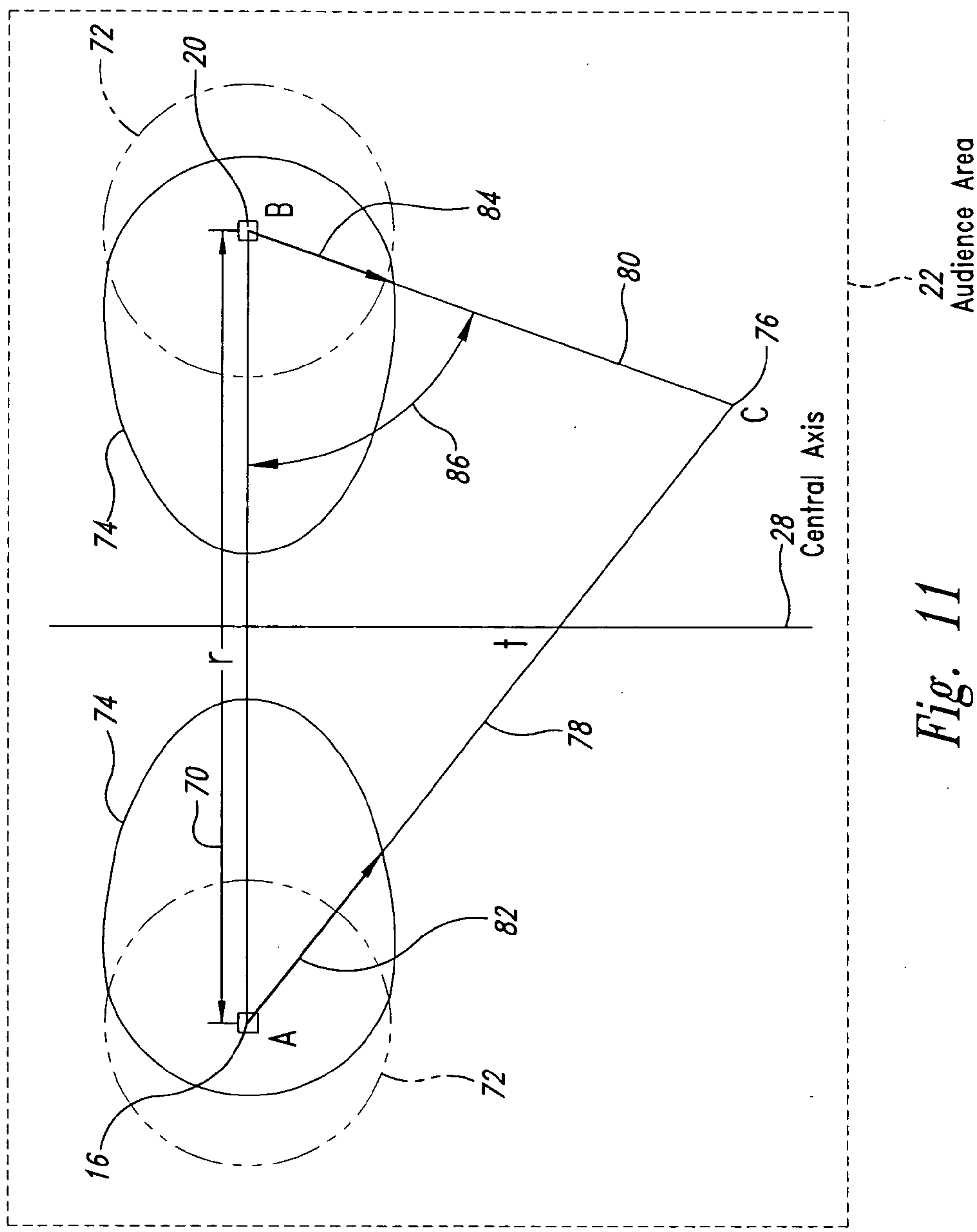
72
20
B
84
80
76
C
86
74
28
Central Axis
22
Audience Area
r
t
74
70
78
82
A
72
16

Fig. 11

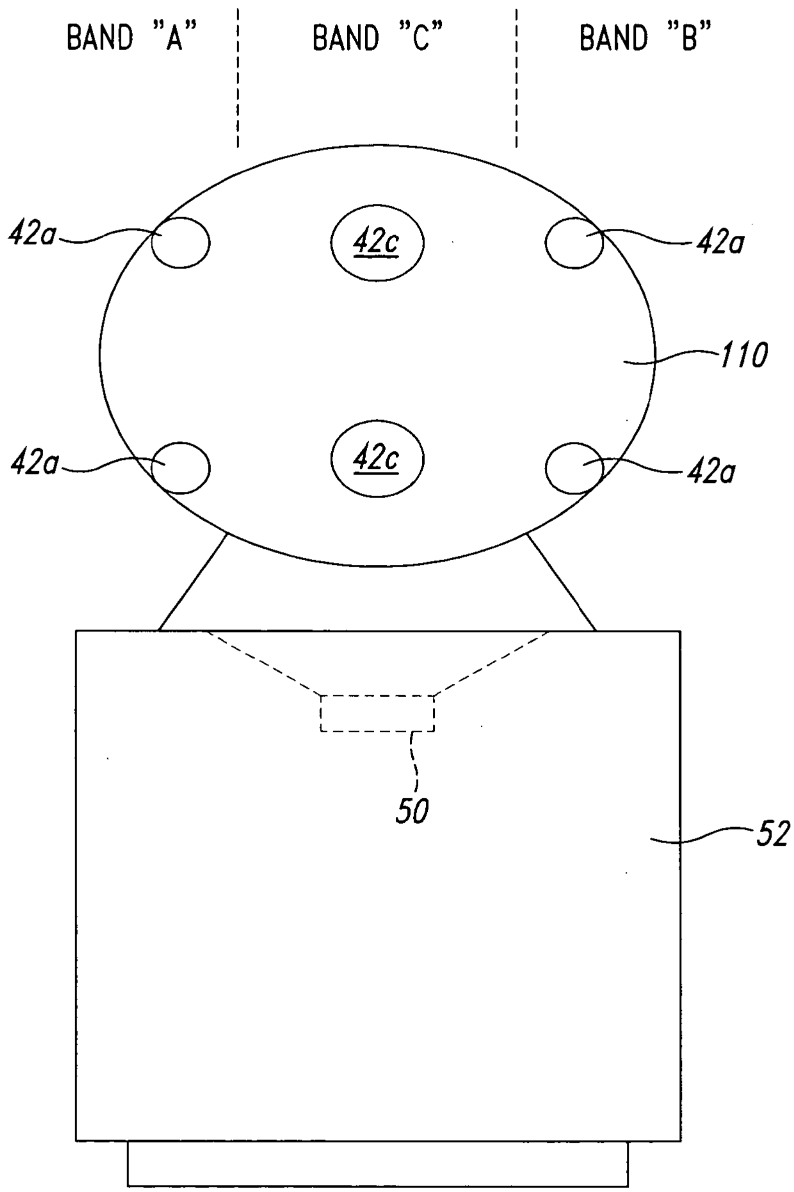

Fig. 12

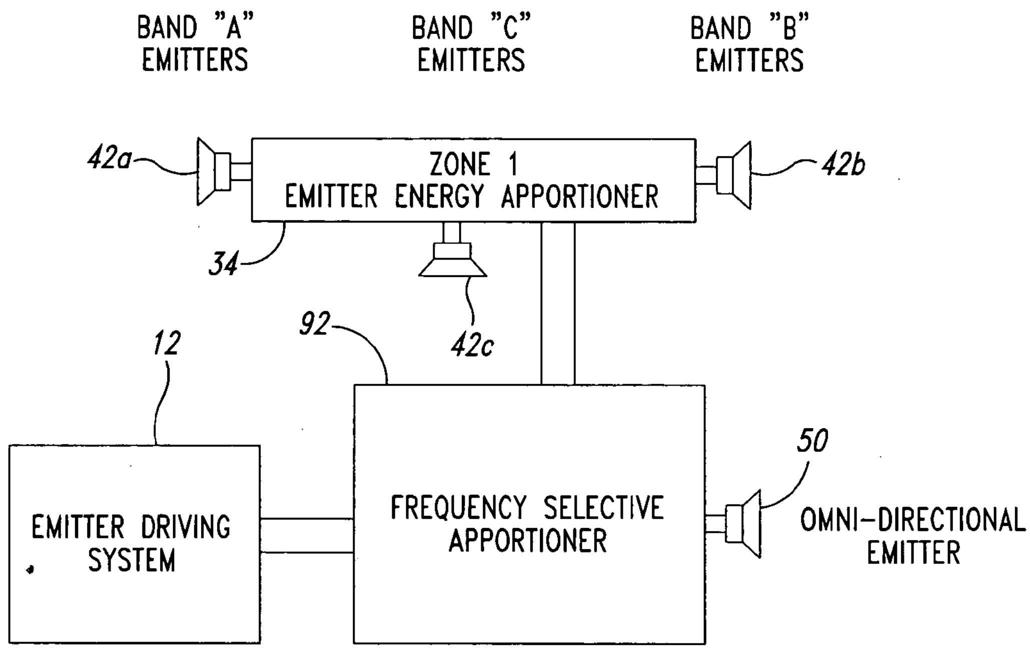
BAND "A"
EMITTERS
BAND "C"
EMITTERS
BAND "B"
EMITTERS
42a
ZONE 1
EMITTER ENERGY APPORTIONER
42b
34
42c
92
12
50
EMITTER DRIVING
SYSTEM
FREQUENCY SELECTIVE
APPORTIONER
OMNI-DIRECTIONAL
EMITTER

Fig. 13

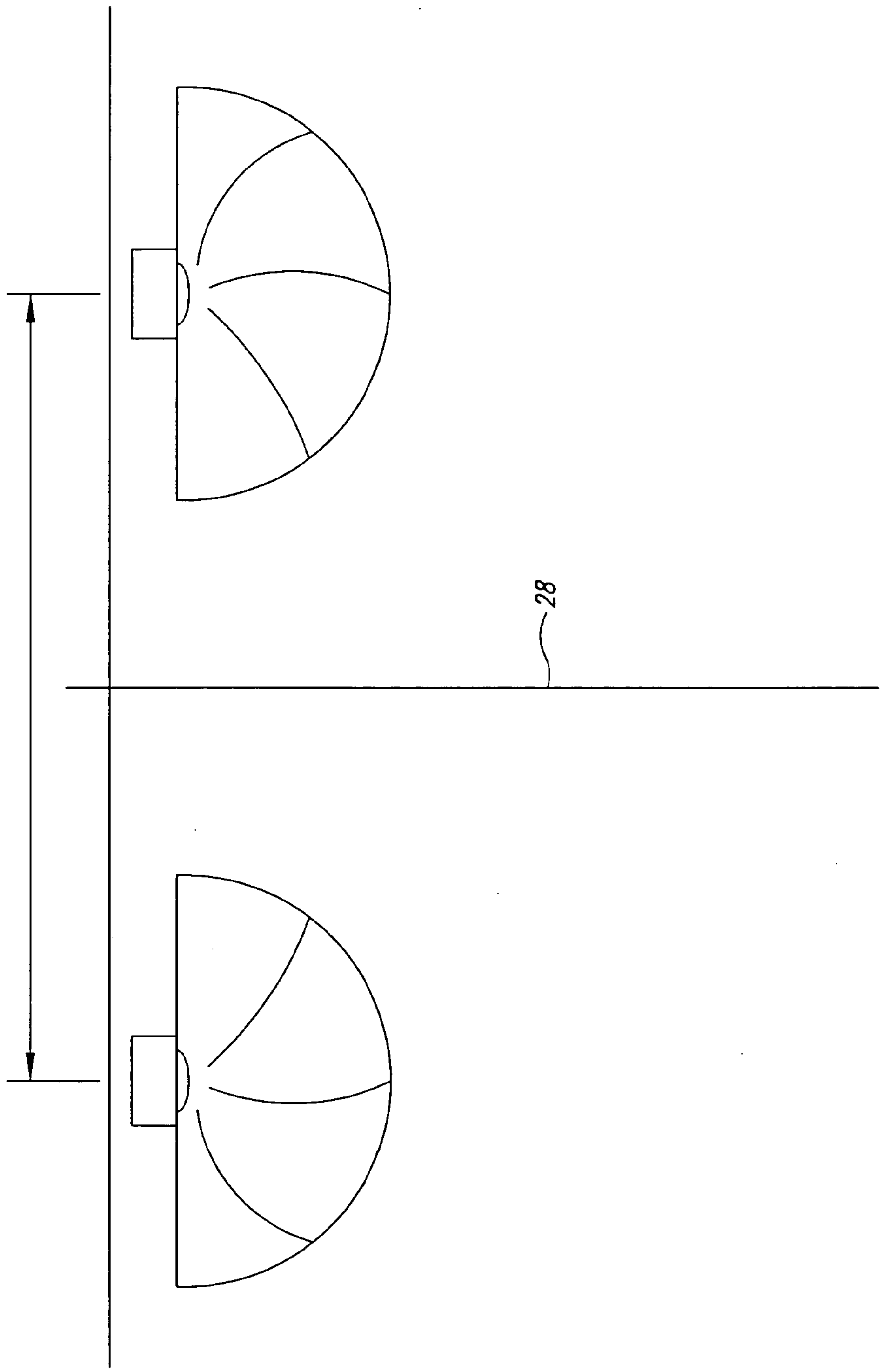

Fig. 14

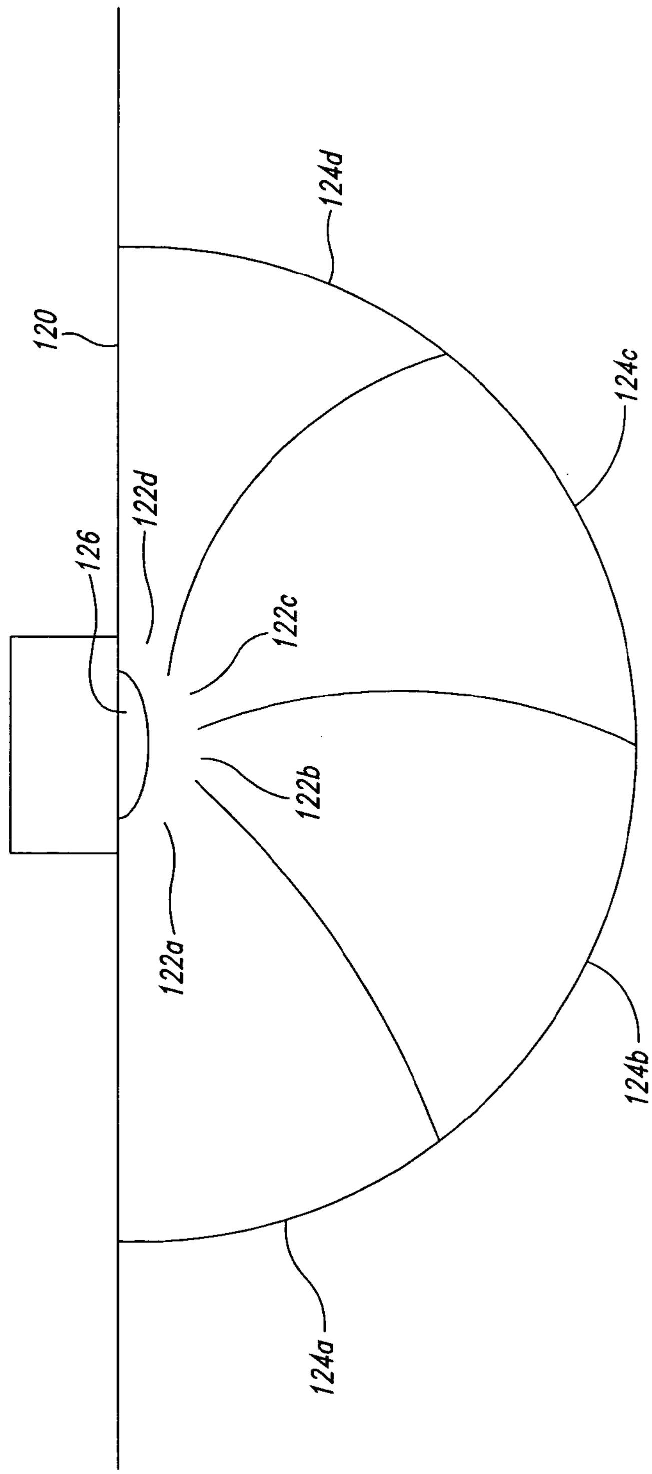

Fig. 15

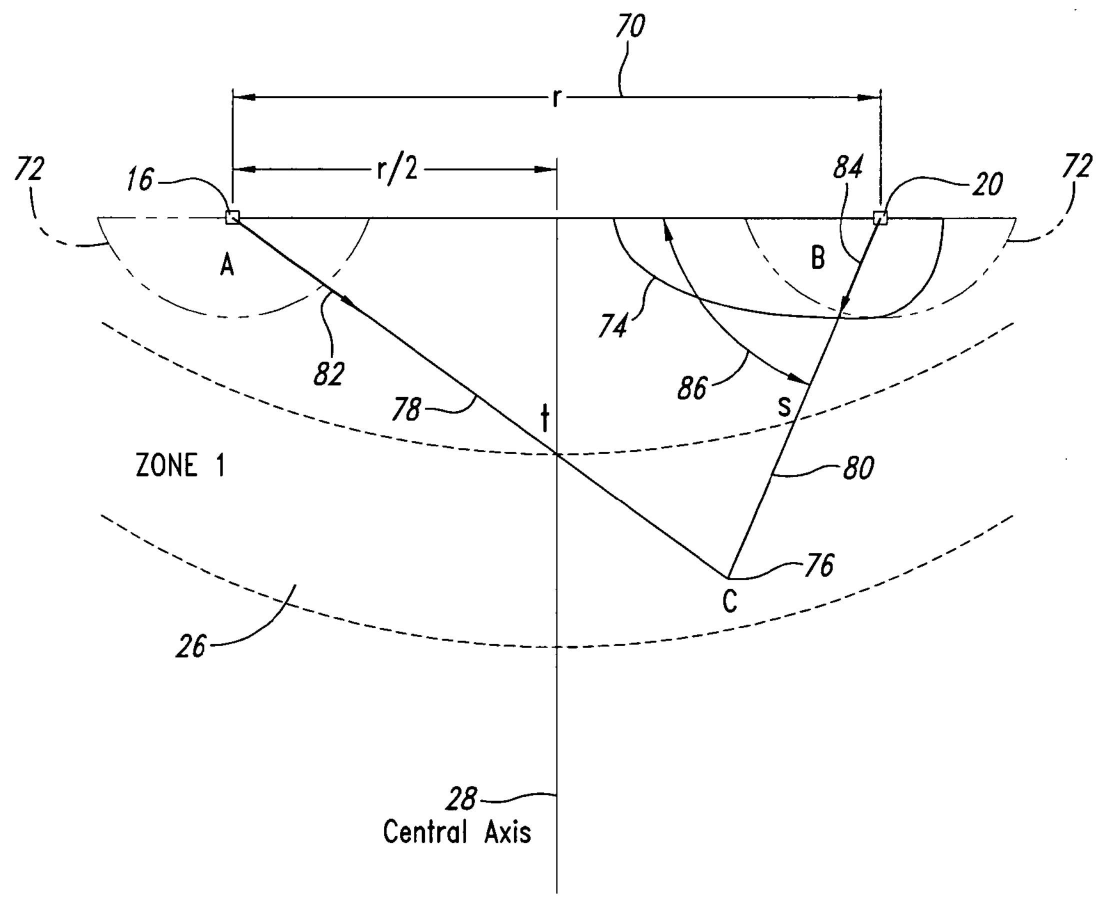
70
r
r/2
72
16
84
20
72
A
B
74
82
86
78
t
s
80
ZONE 1
76
C
26
28
Central Axis

Fig. 16

EXPRESS MAIL NO.: EL981884621US

APPLICATION DATA SHEET

Application Information

Application number::	
Filing Date::	
Application Type::	Provisional
Subject Matter::	Utility
Suggested classification::	
Suggested Group Art Unit::	
CD-ROM or CD-R?::	None
Number of CD disks::	
Number of copies of CDs::	
Sequence submission?::	No
Computer Readable Form (CRF)?::	No
Number of copies of CRF::	
Title ::	METHOD AND APPARATUS FOR SPATIALLY ENHANCING THE STEREO IMAGE IN SOUND REPRODUCTION AND REINFORCEMENT SYSTEMS
Attorney Docket Number::	60399-2
Request for Early Publication?::	No
Request for Non-Publication?::	No
Suggested Drawing Figure::	
Total Drawing Sheets::	17
Small Entity?::	Yes
Petition included?::	No
Petition Type::	
Licensed U.S. Gov't Agency::	No
Contract or Grant No::	
Secrecy Order in Parent Appl.?::	

First Applicant Information

Applicant Authority Type::	Inventor
Primary Citizenship Country::	US
Status::	Full Capacity
Given Name::	Baron
Middle Name::	C.
Family Name::	Dickey
Name Suffix::	
City of Residence::	Mercer Island
State or Province of Residence::	WA
Country of Residence::	US
Street of mailing address::	6809 96th Ave SE
City of mailing address::	Mercer Island
State or Province of mailing address::	WA
Country of mailing address::	US
Postal or Zip Code of mailing address::	98040

Correspondence Information

Correspondence Customer Number:: **22504**

Representative Information

Representative Customer Number::		**22504**

Domestic Priority Information

Application ::	Continuity Type::	Parent Application::	Parent Filing Date::

Foreign Priority Information

Country::	Application number::	Filing Date::	Priority Claimed::

Assignee Information

Assignee name::	
Street of mailing address::	
City of mailing address::	
State or Province of mailing address::	
Country of mailing address::	
Postal or Zip Code of mailing address::	